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EVALUATION OF THE HIGH INTENSITY LIGHT SOURCE ABOARD THE CCGS NORMAN MCLEOD ROGERS

TP 5392 E

S.Y.K. TAM

Prepared for :

Transportation Development Centre
Contract No. 09SD.T8200-0-0505

MPB TECHNOLOGIES INC.

March 1984

Report: 176-1

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M.P. Bachynski
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17. Abstract

A High Intensity Light Source (HILS) consisting of a 50 kW to 150 kW electric arc, developed by MPB Technologies Inc. (MPBT) under the sponsorship of the Transportation Development Centre (TDC) and installed in the CCG icebreaker "Norman McLeod Rogers" under a previous contract, was reactivated for evaluation, demonstration and limited operational use by ships' staff. Prior development of the lamp system to a compact, near operational unit is summarized and its good condition after two years on board ship is described, together with the plumbing and similar problems hampering its operation. Corrective measures are outlined, together with some improvements developed by MPBT on their own initiative. Overall performance in successful demonstrations is commented on briefly, and an alternative reflector design recommended for illumination at distances over 1 km.

See also TP 3432 "Evaluation d'une source lumineuse à haute intensité" by R. Roberge, Gentec inc.,

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17 Resume

Ce rapport appelle les circonstances qui ont mené à l'installation à bord du brise-glace canadien Norman McLeod Rogers d'une source lumineuse à haute intensité, étudiée par MPB Technologies Inc., grâce à l'appui financier du Centre de développement des transports (CDT). Il décrit cette lampe comportant un arc électrique d'une intensité allant de 50 à 150 kW et les études qui ont permis de lui donner un encombrement très réduit et de l'amener à un stade quasi opérationnel; il explique aussi comment, deux ans plus tard, elle est encore en bon état de fonctionnement, malgré les ennuis techniques et autre également décrits. Cette lampe a été remise en état dans le but de pouvoir s'en servir à des fins bien particulières et aussi pour en évaluer et démontrer les performances en service. De plus, le rapport propose des mesures correctrices et fait état des perfectionnements apportés par le contractant, de son propre chef. Il commente brièvement les essais couronnés de succès, tout en recommandant de remplacer le réflecteur en place par un autre réflecteur qui permettrait d'éclairer à plus d'un kilomètre de distance.

Voir aussi le rapport TP 3432, Evaluation d'une source lumineuse à haute intensité, A. Roberge, Gentec inc.

18 Mots-clés	19 Diffusion
Source lumineuse, haute intensité, stabilisation, décharge hélicoïdale de gaz, lampes à arc	Le Centre de développement des transports dispose d'un nombre limité d'exemplaires

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1. BACKGROUND SUMMARY

The development of a gas vortex stabilized arc light source was started in Canada by Tam and Gibbs (1972, 1973, 1974) under the sponsorship of the Defence Research Establishment Valcartier (DSS Contract No. PC 7020231). After this feasibility study which resulted in a successful 160 kW laboratory model, further work was done to develop a self-contained unit with an automatic starting mechanism (DSS Contract No. SR12-143051 sponsored by DREV). This starting mechanism concept was subsequently patented in Canada and the U.S.A. The end result was the successful development of an improved laboratory model, and a prototype, (Tam, Gibbs and Riedel, 1977). Both of the latter models had an automatic starting mechanism, a liquid-cooled reflector and could be operated at power levels from 20 kW to 100 Kw continuously. Instead of 160 kW, a lower power level at 100 kW was chosen as a conservative limit to increase reliability and lamp life.

The most important breakthroughs in the last development were an electronic arc starting mechanism using low voltages and a 45 cm long arc discharge which relied on high voltages (up to 600 V) and low currents (up to 250 amp) to develop high powers. As a result, the electronic self-starting mechanism eliminated mechanical movement required to "draw" a long arc (as was conventionally done). The relatively low starting voltages reduced the severe requirement of the electrode insulation from extremely high voltages. The low discharge current eliminated the inherent technical problem of catastrophic electrode erosion due to high current at the cathode or anode spots. Other achievements were the developments of a liquid-cooled reflector for high power light sources, a closed loop gas recirculation system and a closed liquid cooling system.

In view of the important potential of the vortex stabilized arc as a light source for icebreaking operation, search and rescue operation, navigation and other transportation applications, further work was supported by the Research and Development Center, Transport Canada to develop a High Intensity Light Source (HILS) for icebreaking missions and other marine applications. The overall objective was to develop a package which would be proof against sea water, moisture and shipboard vibrations. Since this development involved new technologies, details of the relevant marine specifications were to be worked out later.

For marine applications significant further development was required. These included (i) a weather proof cabinet for the light head, (ii) a water proof power supply suitable for high power vortex-stabilized arc discharges, (iii) a new discharge circuitry which would eliminate a separate power supply for arc starting, (iv) a cooling system with an antifreeze solution unaffected by radiation from the arc, (v) a different heat exchanging system which would utilize sea water for heat removal, and above all (vi) a sea-water proof package where all the systems and their interconnecting components could be installed above deck. A 50 kW unit was chosen as adequate for marine applications.

During the development of HILS 1, much effort was devoted to the design and tests of a rotatable light head with a sea water proof cabinet. Its rotatibility required some serious considerations on the design and tests of manifolds for gas and liquid coolants. The power control was redesigned so as to reduce the size and weight of its previous equivalent by 80% approximately and to have a completely enclosed water proof housing with cooling arrangement.

Significant problems were encountered in developing the closed loop cooling system with an antifreeze coolant. The greatest difficulties were to choose and test a suitable, clear, transparent antifreeze coolant unaffected by strong light radiation and suitable hydraulic components. The latter should not colour or contaminate the transparent coolant nor should it be deteriorated by the coolant over a long period of time. Also it had to meet marine specifications. It turned out that most conventional hydraulic components would meet part of the requirements only. In fact some of the requirements could not be specified quantitatively in terms understandable by the suppliers. The final cooling system was fabricated after much effort of searching and experimentation.

The individual subsystems were developed and tested in the laboratory separately. They were tested again after being integrated with the HILS 1 package. The light head was then moved outdoors in February, 1979 to undergo environmental tests under extreme cold and windy weather conditions. Other components remained indoor since it was then decided that they should be below deck during shipboard applications. On February 5, 1979, a field demonstration was presented to guests from various government and provate agencies.

HILS 1 remained on the same site for the next three weeks. It was delivered to icebreaker, N.M. Rogers, on February 21, 1979, for evaluation. Shipboard installation for evaluation purposes was done by a separate contractor, arranged by the Canadian Coast Guard and was completed on March 1, 1979. A demonstration was presented to the crew on March 2 by members of MPB Technologies Inc. Another demonstration was presented to the scientific authority, Mr. R.H.F. Dillon on March 5, 1979. This development is summarized by Tam, Gibbs, Riedel and Smith (1980).

Based on the above prior developments a brochure on a high power light source presenting the principles of operation, specifications and potential applications together with pictures of the marine trials was prepared by MPB Technologies Inc. The goal was to stimulate possible commercial interest in the application of high intensity light sources. A copy of this brochure is contained in Appendix 1 of this report.

The HILS 1 system remained aboard the icebreaker N.M. Rogers for several years with initial intermittent use by the crew. After this period in the marine environment, MPB Technologies Inc. was requested by the Transportation & Development Centre (TDC) to make the Light Source operational again and to conduct a series of evaluation trials in order to ascertain damage which might have occurred to the light system from its presence for an extended period in the marine environment, to check out areas where improvements were possible in order to enhance reliability and to determine from operation of the source under actual conditions what further development should be conducted to determine the operating characteristics which would be best for marine uses.

The remainder of this report is devoted to the re-commissioning, trials and evaluation of the marine high intensity light system which were conducted after the system had been on the ice breaker for several years. The following chapter describes the initial condition of the system, the problem areas and the development and remedial action necessary. Chapter 3 summarizes the results and observations arising from the operational trials conducted and indicates areas for future development.

A summary of the detailed activities conducted during the evaluation is attached as Appendix 2.

2. EVALUATION TRIALS

2.1 Condition of HILS Prior to Trials

Before any evaluation trials were made, note was taken of the various subsystems of the HILS. The condition of these subsystems were as follows:

2.1.1 General Conditions

On visual inspection, the various parts of HILS appeared in good condition. However, the plastic hoses which connected the light head on the mast and the gas and coolant system were found to be slightly loose at connecting fittings. However, all electrical connections had been severed and extensive servicing was necessary to restore these.

2.1.2 The Light Head

Despite the weathering after two years and several trips to the arctic, the light head was in remarkably good condition. No apparent deterioration or rust was observed on the light head which included the weatherproof housing the reflector, the rotary positioner (turntable) and the various components inside the arc chamber. The coolant inside the light head appeared clear and clean. The only part that suffered significant rusting was the unpainted mounting plate on the mast. This mounting plate was fabricated by a contractor without the supervision of personnel from MPB Technologies Inc. and was not part of the light head. However, the rusting was only superficial and should not affect the structural integrity of the mounting plate.

2.1.3 Gas and Coolant System

Visual inspection on the gas and coolant systems suggested that they were in good condition. Further examination revealed the following problems:

i) Dirty Coolant Filter - Under normal conditions, the coolant system should be almost completely free of air and the coolant filter should not rust. This had been confirmed during an inspection one year after the HILS was installed on the ice breaker N.M. McLeod Rogers. However, the coolant filter was found to have rusted significantly suggesting some air might have been introduced in the closed loop cooling system.

ii) Loose Hose Connections - The plastic hoses which connected the light head on the mast and the gas and coolant systems below deck were found to be loose at the hose connections.

iii) Sea Water Pump - The sea water pump, which had been installed by an independent contractor hired by TDC, was found to be faulty. The bearing apparently had been seized. The electric motor had been overloaded and burnt and needed to be replaced.

2.1.4 Main Power Control

There was no apparent deterioration inside and outside the main power control unit. Three resistors on the 440V three phase ac power control circuit card showed signs of overheating. However, numerous diagnostic tests showed that the control circuit worked well. The overheating probably occurred during previous testing on the circuit board itself before the shipboard installation. These resistors were replaced.

2.1.5 Remote Command Console

The remote command console appeared to be in good condition.

2.1.6 Safety Interlocking Systems and Switches

Diagnostic tests showed that the interlocking switches and the complete systems were in good working order.

2.2 Problem Areas and Corrections

The following are problem areas and corrections made before and during the evaluation period:

2.2.1 Leakage at hose fittings

All defective hose fittings were replaced and tightened to the proper specifications.

2.2.2 Defective Sea Water Pump

The defective sea water pump was repaired and the electric motor was replaced by a subcontractor, Gen-Tec of Quebec City.

2.2.3 Dirty Coolant Filter

The dirty coolant filter was replaced. However, extensive tests were conducted to track down leakage of the coolant system until no apparent leak was detected.

2.2.4 Gas Bubbles in Cooling System

Mysterious air bubbles were found inside the cooling jacket of the arc chamber. These bubbles would appear immediately after HILS was turned on. After hours of continuous operation, the bubbles would gradually grow in size and would combine into a long bubble extending to about 1/3 the discharge tube length. Eventually the automatic protection switch would shut off the HILS and the closed loop gas system would show a reduced pressure Extensive tests showed no unusual defects in any part of HILS. The discharge tube was removed, brought back to MPB Technologies Inc., examined and tested on a separate facility in the laboratory. Despite exhaustive tests, replacement of parts and loan of new discharge tubes from MPBT, the source of the malfunction could not be identified. This problem lasted for many days. It prevented daily operation by the ship's staff until a short while before the test demonstration

when a short piece of hose inside the coolant system was found defective (leaking). Once a new piece of hose was installed, no bubbles showed in the discharge tube anymore after many hours of operation. This enabled a successful demonstration at Chicoutimi on March 4, 1981.

2.2.5 Starting Mechanism

Although HILS was started quite readily before delivery to TDC and installed on the icebreaker, its ignition became erratic after the gas recirculation was contaminated during its installation by an independent contractor not supervised by MPB Technologies Inc. The starting problem was solved after the starting circuit was replaced by a new version developed in-house by MPB Technologies Inc.

2.2.6 Light Backscattering

Due to the location of the HILS and its original floodlight design concept, there was significant backscatter of light from the ship's front deck. This backscatter was found to significantly reduce visibility in front of the icebreaker. In view of this, a very simple ingenious and effective light baffle was designed by the Scientific Authority at TDC and fabricated by Gen-Tec, Quebec. The light baffle could be firmly mounted and removed easily on the HILS light head in minutes. It helped to direct the flood light in the forward direction practically removing all side light and backscatter from the ship's deck.

After the backscatter from the ship's deck was removed, backscatter from the ice surface closer to the ship (about 30 to 100 metres) had a tendency to deteriorate visibility over a longer distance (up to a few km). This led the scientific authority at TDC to suggest beam shaping and the development of a new reflector for a narrower beam.

After a series of diagnostic tests, steps taken to repair or replace any defective systems, the HILS was recommissioned and tested at various locations on the St. Lawrence. These tests were conducted in the presence of different observers invited by TDC and MPB Technologies Inc. A chronology of the evaluation trials is presented in Appendix 2.

3. SUMMARY AND CONCLUSIONS

The results of the 1981 evaluation on the TDC/MPBT HILS can be summarized as follows:

3.1 Problems Discovered During Evaluation

3.1.1 Leakage

Leakage due to joints which connected the plastic hoses between the light head and the gas and coolant systems caused great difficulty. This was probably due to the "fatigue" of plastic material at the connector fittings. After the plastic material was squeezed for a long time and then was subjected to extreme weather and temperature changes, it had a tendency to deform and lose some of its elasticity. As a result, the plastic hoses became loose at the connector fittings.

The cause of this problem was the use of a temporary test facility as a long term installation. The plastic hoses would be adequate for temporary uses over several months. Proper copper piping would have avoided this problem. The correction of the problem would eliminate the gas bubbles and the problem of the coolant filters.

3.1.2 Starting Mechanism

The original electronic starting circuit was adequate for a clean, uncontaminated discharge tube with a clean gas recirculation system. However, it became less reliable once the gas system was contaminated by impurities such as grease applied to the hose fittings inadvertently. This problem was solved by replacing the initial starting circuit by a new circuit developed by MPB Technologies Inc. This new circuit provided a more energetic starting pulse with the optimum pulse shape for starting the HILS automatically and reliably.

3.1.3 Sea Water Pump

The sea water pump was installed by an independent contractor not hired nor supervised by MPBT. It should have been the simplest of the complete system. However, it had repeatedly malfunctioned (several times in a single winter season) causing damage to the motor and electric circuit breaker overload inside the HILS main power control. In fact this problem would never have arisen if a proper water pump similar to the one in the coolant system had been used.

3.1.4 Light Backscatter

Historically the HILS was designed as a flood light, the illumination was expected to cover a large area. The backscatter on the ship's deck due to the wide beam would naturally result in backscatter especially when the HILS was located a significant distance from the bow of the ship. Light baffle such as the one used during the trials would reduce the backscatter but would also remove some light and reduce the total output illuminating power of HILS.

A proper approach should be the development of a reflector designed to provide a more collimated light beam. This would provide a "search light" type beam. Another possibility is to have a special mount on the ship, away from obstructions. A reflector which could be altered from a collimated beam to wide area illumination would, of course, be ideal.

3.2 Overall Performance

a) The TDC/MPBT HILS gave satisfactory performance in light output, improved reliability in starting and general operation.

b) It gave floodlight illumination providing good visibility over an area of about 400m around the ship.

c) The HILS gave reasonable visibility of objects 1000m away.

d) The HILS was simple to operate with the remote control module. Its rotatable light head was compact for its power.

3.3 HILS Development Funded by Government

The original HILS is described in TDC report "Development of a Vortex Stabilized Arc Source for Marine Application" by S.Y.K. Tam et al, 1980. This included the following:

a) Light head with rotary positioner

b) Gas and cooling system

c) Main power control

d) Remote control console.

The above were developed as part of the government funded contract.

3.4 Improvement and Contribution by MPB Technologies Inc. to the HILS Program

The following were contributed by MPB Technologies Inc. as part of their in-house company funded efforts:

a) New, improved starting system - This system was developed by MPB Technologies Inc. in-house and was installed in the TDC/MPBT HILS.

b) Loan of light heads - Several light heads and test facilities at MPB Technologies Inc. were loaned to the evaluation trials.

c) Development of cooling arrangement to avoid coolant deterioration.

d) Series of laboratory, reliability tests to run HILS over 100 hours.

e) Preparation and printing of "Megalite" advertising brochures (see Appendix 1)

f) Effort to secure a license from Canadian Patent Development Ltd. based on a patent by Drs. S.Y.K. Tam and A.K. Ghosh of MPB Technologies Inc.

4. RECOMMENDATIONS

In view of the success of the existing TDC/MPBT HILS, further development is recommended along the following lines:

4.1 Advanced Reflector

The several evaluation trials on the icebreaker Norman McLeaod Rogers showed that the HILS was useful as a wide beam floodlight giving good visibility over an area about 400m around the ship. However, visibility over 1000m was found to be less than adequate. Further work should be done to develop a new type of reflector which would improve visibility over a long distance by collimating the light beam over a few degree beam width rather than the 180^{o} beam width in the present design.

4.2 Portable HILS

The successful demonstrations on the Icebreaker Norman McLeod Rogers have shown that the TDC/MPBT HILS has the potential for a variety of applications either as a flood light or a search light. However, due to logistic problems and limitations imposed by the shipboard "semi-permanent" installation, repairs and improvements between tests were difficult and its potential has not been fully demonstrated. We now recommend the construction of a portable HILS using components from the existing HILS and additional hardware.

A portable HILS on a self-contained vehicle or transportable palette will solve many of the problems mentioned before. It enables tests and demonstrations in different environments and applications at short notice. As a test bed for improved subsystem designs, it is cost effective because repairs, modifications and improvements between field tests can be done in the "laboratory" rather than in the field. Since it is transportable, it enables cost effective field tests or demonstrations at varying sites for prospective users.

This portable HILS should be built as soon as possible so as to provide a test bed for the reflector and for demonstrations.

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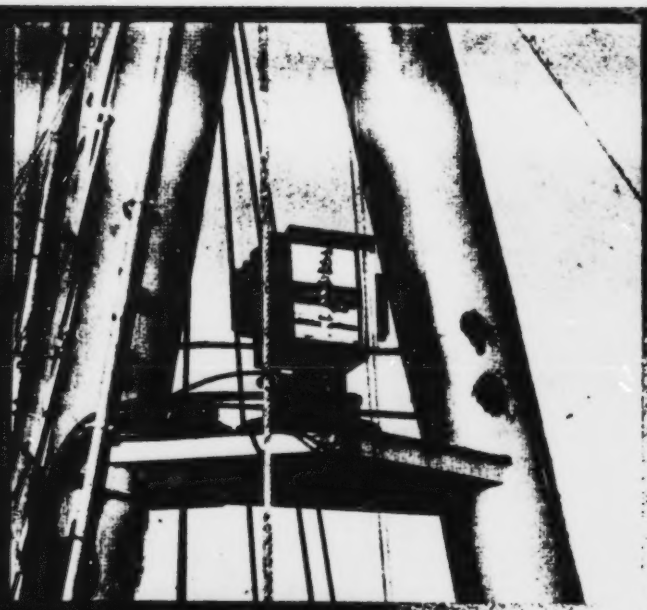
APPENDIX 1

AFB



galite

A 50 to 150 kw high power light source

Features

- High Power: 50 kw - 150 kw.
- Compact, Weatherproof, Rotatable Light-Head.
- Instant Starting.
- High Efficiency.
- White Light (Continuous) Spectrum.
- Long Life, Easily Serviceable.
- Choice of Wide or Highly Directional Beam.
- Transportable.
- Operates Under Arctic Conditions.
- Light-Head Remote From Auxiliary Equipment If Required.
- [illegible]otely Controlled.
- [illegible]ntained.

Megalite is a high power arc lamp developed by MPB Technologies Inc. Its lighting element is a long (450 mm) self-starting vortex stabilized argon arc discharge **(See Fig. 1)**. In contrast with the Xenon short arc (usually a few mm long) which develops high powers within a small volume at high currents and low voltages, **Megalite** can operate at a considerably higher power by maintaining a much higher discharge voltage in a long arc while keeping the discharge current well below the limit of electrode deterioration. As a result, many problems associated with extreme electrode currents and localized energy concentrations are avoided. Our own invention of a low voltage electronic starting system also eliminates the severe problems of high voltage insulation. Compared with commercially available mercury arc lamps, **Megalite** has a continuous radiation spectrum **(See Fig. 2)** instead of a line spectrum, can be started instantaneously (with no warm-up time) and, above all, can deliver over a hundred times more light output in a light-head of comparable dimensions.

Depending on specific applications and options, a typical self-contained **Megalite** system consists of a light-head, a rotary positioner, a main power control, a gas recirculation system, an antifreeze cooling system and a remote command console **(See Fig. 3)**. A motor-generator unit could be used to power the system in remote locations.

Principle of Operation

The lighting element of **Megalite** is a dc gas vortex-stabilized arc which differs from a conventional arc in having a stabilizing gas vortex around its arc column. The working gas is injected around the cathode tangentially to the inside circumference of the chamber **(See Fig. 1)**. As it traverses the arc chamber, its spiralling action creates a radial pressure gradient favouring the conduction of electric current along the chamber axis. The spent gas is exhausted through the anode. The arc is ignited with a patented technique and is maintained by a dc power supply. Since the arc column is at a temperature typically above 10,000°K, the gas vortex acts as a colliminating and insulating jacket to protect the chamber wall from overheating.

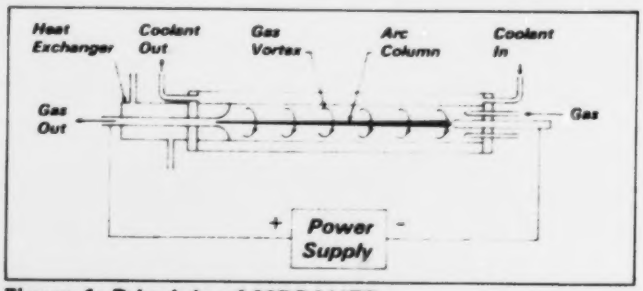


Figure 1: Principle of MEGALITE

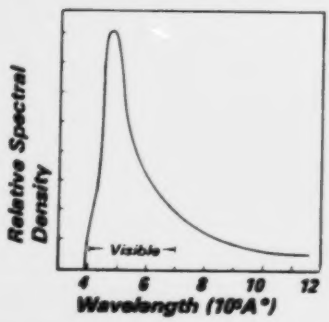


Figure 2: Typical radiation spectrum of MEGALITE.

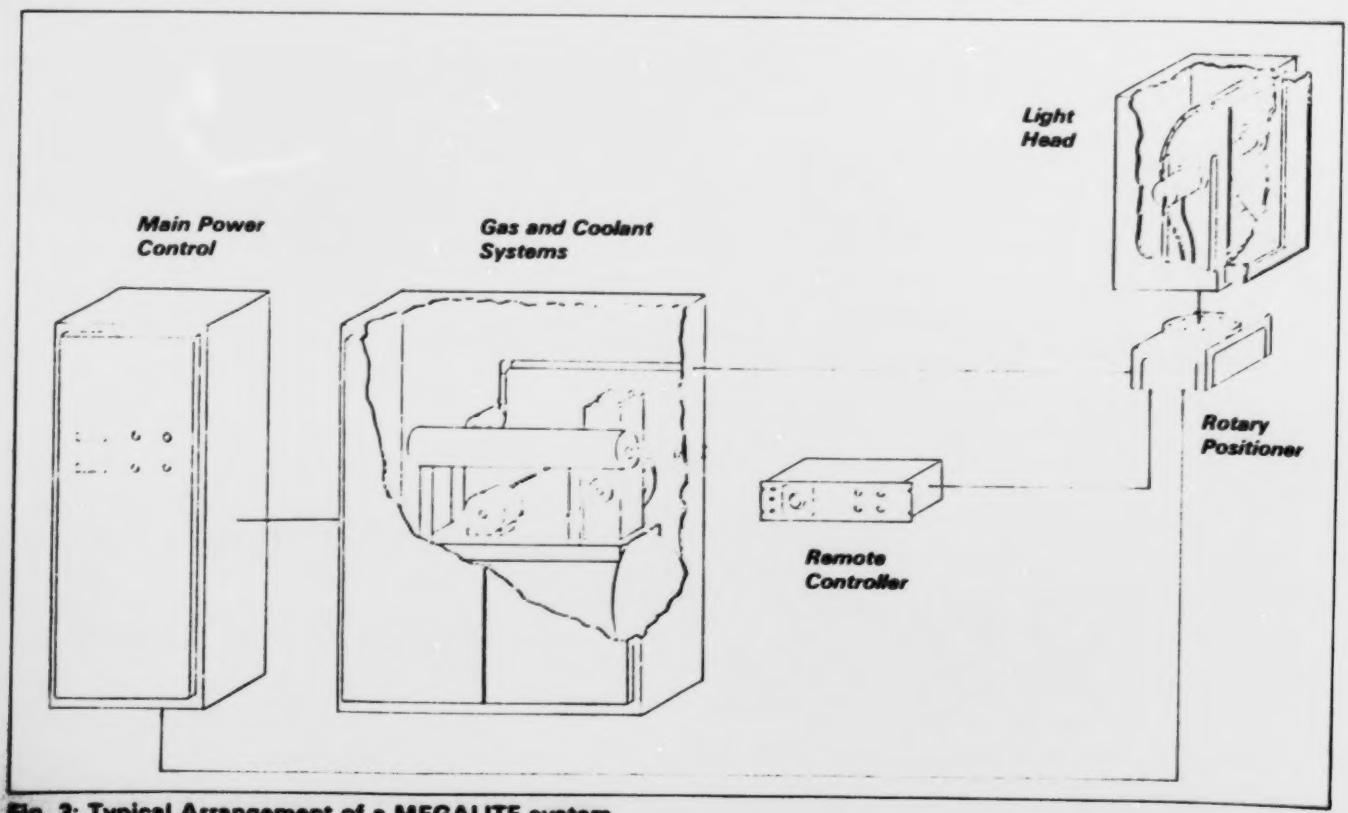


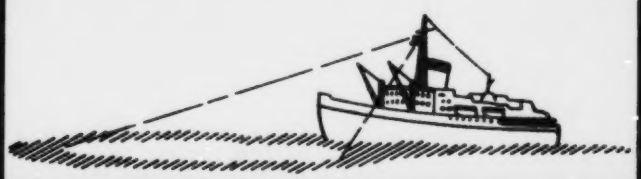
Fig. 3: Typical Arrangement of a MEGALITE system.

Specifications

INPUT POWER	Models available from 50 kW to 150 kW
ARC LENGTH	Up to 450 mm
POWER REQUIREMENTS	3 phase AC, 440 or 600V
GAS SYSTEM	Closed loop
COOLING	Closed loop antifreeze
LUMINOUS EFFICACY	67 lumens/watt
COLOUR TEMPERATURE	6000°K
BEAMWIDTH	10° to 180° depending on choice of reflector
LIFE EXPENCTANCY	Unlimited with regular maintenance; light element replaceable at relatively low cost
TYPICAL DIMENSIONS	76 cm (height) x 60 cm (width) x 40 cm (depth)

The high power, rugged construction, instantaneous push button starting and compact and rotatable light head enable the MEGALITE to fulfill special requirements which cannot be met by conventional light sources. With a light-head about the size of a conventional 1kW arc lamp, MEGALITE provides a convenient portable source for illuminating large areas for the following applications:

Marine Applications

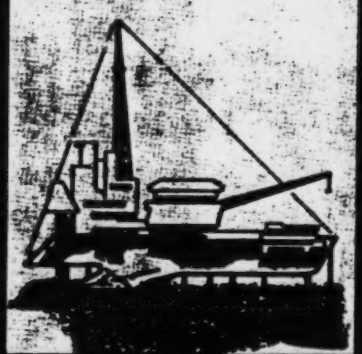


- Navigation aids
- Icebreaker operations
- Harbour surveillance
- Underwater illumination

Construction

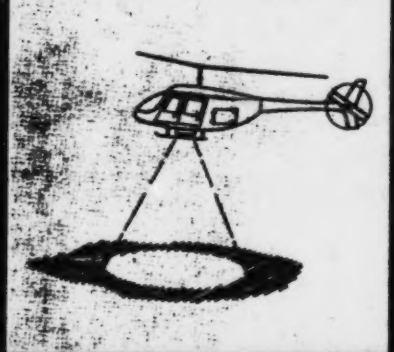
- Laying pipeline
- Hydro projects
- Building sites
- Area lighting

Oil Exploration



- Illumination of site and oil rig
- Underwater repair
- Surveillance of pipelines

Emergency Lighting



- Search and rescue (shipwrecks, plane crashes, power blackouts, etc.)
- Oil Spills
- Law Enforcement

- Solar simulator
- Colour TV and Movie filming
- Greenhouses

APPENDIX 2

Summary of Activities

on the

Evaluation of the High Intensity Light Source Aboard the CCGS Norman McLeod Rogers

DSS Contract No: 09SD.T8200-0-0505

Prepared for the

Transportation Development Centre
1000 Sherbrooke Street West, Montreal, Que.
H3A 2R3

Prepared by _____ Approved by _____

Dr. S.Y.K. Tam
Project Leader

Dr. M.P. Bachynski
President

Date: November 18, 1981

SUMMARY OF ACTIVITIES ON THE

EVALUATION OF THE HIGH INTENSITY LIGHT SOURCE (HILS) ABOARD THE CCGS NORMAN McLEOD ROGERS

The following is a summary of the activities since the start of this evaluation program:

Sept. 5 to October 29, 1980:

Preparation

This involves miscellaneous telephone discussions and meeting with TDC personnel and Ms Terry Gillies regarding preparation of drawing.

October 30, 1980:

Meeting at Quebec City

A meeting was held at Quebec City with personnel from TDC and Gentec. Preliminary inspections and technical discussions were conducted on and off the Icebreaker McLeod Rogers.

October 31 to November 6, 1980:

Planning

Work included planning, preparation of spare kits and acquisitions of materials.

November 7, 1980:

Planning Meeting at MPB Technologies Inc.

A planning meeting was held at MPB Technologies Inc. with personnel from TDC and Gentec. Plans, schedules, and technical details were discussed.

November 8 to 16, 1980:

Preparation

Work included telephone discussions with Gentec, preparation of parts and tests for spare light head, preparation of test equipment, materials and tools for anticipated work on the Icebreaker McLeod Rogers.

November 17, 1980:

Inspection of HILS on Icebreaker at Quebec City

Work included visual inspection of HILS's subsystems, operating subsystems, restarting rotator, pumps, cooling system, gas recirculation system, checking safety interlocks such as thermal and pressure switches. Initially, rotator did not work due to cold weather, until the heater in lighthead was turned on for 6 hours. Gentec personnel was shown procedure of refilling coolant and gas.

November 18 to 23, 1980:

Preparation

Work included preparation of light head, and miscellaneous test equipment, and telephone discussions with TDC and Gentec personnel. Spare light head was loaned by MPB Technologies Inc. at no cost to the contract.

November 24 to 25, 1980:

Attempt to Restart HILS on Icebreaker at Quebec City

Since visual inspection of light head showed gas bubble in coolant leakage in cooling was suspected. Cooling system was flushed and refilled. Initial attempts to turn on the gas and coolant recirculation systems were not successful. Diagnosis revealed unusually low seawater pumping pressure. Recirculation systems and all safety interlocking switches worked properly after the seawater pump pressure interlocking switch was readjusted. Attempts to start the HILS were not successful. A circuit breaker on the electrical supply line on the shore was overloaded.

November 26 to December 16, 1980

Laboratory Preparation

The spare light head was reinstalled in the laboratory of MPB Technologies Inc. and tested under similar conditions as those in the icebreaker. It was removed from the test set-up and repacked for the next anticipated trip to the ship.

December 17 & 18, 1980:

2nd Attempt to Restart HILS at Three Rivers

The discharge tube in the HILS' light head was replaced by the spare unit. The cooling system was refilled. Fittings in both the gas and coolant systems were checked under pressure and faulty connectors were replaced. A faulty electrical circuit in the HILS tripped the alarms in the ship's engine room. Lengthy diagnosis revealed that the seawater pump was faulty. HILS could not be started or tested with the faulty seawater cooling system.

December 19, 1980 to January 14, 1981:

Miscellaneous Preparation

Work included phone discussions, meetings, administration and paper work.

January 15, 1981:

Meeting with Scientific Authority to review status of contract.

January 19, 1981:

Tested light head in laboratory with MPBT's switch. Purchased parts to build switch.

January 23, 1981:

MPB Technologies Inc. kept close communication with Gentec while the latter was repairing the seawater pump and motor.

February 9, 1981:

The HILS was recommissioned with the new switch. Instructions were given to the crew of McLeod Rogers and the chief engineer (Mr. Cote) on the principle and operating procedure of the HILS. The crew was instructed to operate the HILS for half an hour each night unless unusual problems developed.

February 12, 1981:

Mr. Cote reported that the seawater pump was leaking badly. However, the ship's crew had used the HILS as a flood light for 4½ hours during an important icebreaking mission. However, a long bubble developed in the cooling system.

February 17, 1981:

The seawater pump was repaired by Gentec. MPB Technologies Inc. helped to recommission the HILS again.

February 23, 1981:

A demonstration was given to the Scientific Authority and the ship's crew at Three Rivers. A light baffle which was already installed on the light head by Gentec to control the beam divergence was able to reduce unwanted backscattered light. The HILS was turned on and off reliably.

March 4, 1981:

A demonstration was conducted at Chicoutimi in the presence of representatives from the Coast Guards and Petro Canada. The HILS was turned on and off reliably many times. The demonstration lasted about two hours while the ship was icebreaking or cruising along chosen routes in the Saguenay River. With the light baffle installed, the HILS illumination enabled one to distinguish objects on the shore line at 2 to 3 km away. When the baffle was removed, the backscattered light from the ship's hull reduced visibility significantly. All parts of the HILS functioned reliably during the tests.

Summary of Results

Results of the 1981 evaluation on the TDC/MPBT HILS can be summarized as follows:

a. The TDC/MPBT HILS gave satisfactory performance in light output, improved reliability in starting and general operation over the previous years.

b. It gave good visibility over an area of about 400 m around the ship.

c. Despite a width beamwidth of about 180° and strong backscatter from the ship's hull which significantly reduces visibility, the HILS gave reasonable visibility on objects 1000 m away.

d. A new type of reflector would be required for icebreaker operations in the rivers where narrow beam search light illuminating modes appeared more preferrable.

e. As it is, the HILS gave excellent illumination for search and rescue operations.

f. With some modifications on the reflector, to concentrate illumination within a beamwidth of 45°, the HILS should give good visibility over 2000 m and should be extremely useful for tanker or icebreaker navigation in the Arctic.